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A REVIEW OF APPLIED ENTOMOLOGY IN THE BRITISH
EMPIRE.*

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*The Annual Address to the Entomological Society of America, delivered at Columbus, Ohio, on December 29th, 1915.

In the selection of the subject of my address I had as my main motive the bringing of the entomologists of this country into closer touch with a large body of entomologists who are studying an infinite variety of problems in those widespread territories of the earth's surface that together constitute the British Empire. This more intimate acquaintance is desirable for many reasons, but I will refer only to two of them. First, our Society recently decided to extend its membership outside the confines of North America and as a result a number of British workers, which number I am confident will increase, have been included on our membership rolls; I wish to introduce these members and some of their problems to you. Secondly, it is becoming increasingly apparent that the control of insect pests and the successful prosecution of entomological investigation, be it along practical or purely scientific lines, must be along international lines. Our experience, especially during recent years, has clearly demonstrated this fact, particularly in regard to the control of insects by their natural enemies. From the time when Koebele visited Australia in 1885 and brought the now famous Coccinellid *Novius cardinalis* to save the citrus groves of California from destruction up to the recent world tour of Silvestri in search of parasites of the fruit-flies, we have had repeated instances of the incalculable value of international co-operation; but it would involve too great a digression to mention even the more important of these. In this line of investigation alone there lie immense possibilities which will be made more easy of realization to the benefit of all concerned by a more intimate knowledge of other workers and their problems in other parts of the world. Such a review as I propose to give will, I feel confident, show clearly how the British Empire by its widespread character and diversity of conditions of every kind, offers an unequalled opportunity for international co-operative effort, particularly to the Entomologists of the United States. The establishment of a chain of workers in all the continents which would result from such co-operation would have beneficial results of the most far reaching character on the entomological work of the future. If I am able to further the object to which I have referred, I shall consider that the time I am about to take up has indeed been well spent.

The countries that enjoy the benefits of British forms of government comprise territories from equatorial to arctic and antarctic latitudes; they include some of the most worthless and barren regions of the world's surface and some of the richest and most fertile. Consequently we find every type of vegetation, every kind of crop and every form of insect life to which such vegetation or crop may serve as sustenance. In addition there are few types of insect-borne disease that are not found somewhere within British domains. It will not be possible, therefore, to do more than briefly touch upon the more outstanding features of the work that is being carried on in those countries by an ever increasing body of highly trained and enthusiastic workers. And here I would remind you that it is one of the chief characteristics of the British entomologist that he usually follows his profession on account of his enthusiasm for the subject, and in spite of the remuneration that he receives and the natural difficulties with which he has to contend.

BRITISH ISLES.

The Imperial Bureau of Entomology.—The formation of the Imperial Bureau of Entomology in 1913 was the outcome of an effort made a few years earlier to further entomological investigations in the British possessions in tropical Africa. Early in 1909 Dr. A. E. Shipley, Master of Christ's College, Cambridge, drew up a memorandum, with some slight assistance from me, for the Secretary of State for the Colonies, Lord Crewe, and as a result of this a meeting was called in March, 1909, to discuss the formation of an entomological research committee for the study of entomological problems, particularly those relating to tropical diseases, in tropical Africa. Such a committee was formed that year and it included the chief experts in entomology and tropical medicine in Great Britain and Ireland, with Lord Cromer as Chairman. Its work fell under three divisions, namely, the carrying on of investigations and entomological surveys in tropical Africa, for the purpose of which two travelling entomologists, Mr. S. A. Neave and Dr. J. J. Simpson, to whose work reference will be made later, were employed; the determination of entomological material, and the publication of the work so accomplished, for which purpose the *Bulletin of Entomological Research* was started as a quarterly journal.

The valuable service rendered by this committee soon led to an enlargement of its scope. After a consideration of the matter by the self-governing dominions, and a conference of the committee and of the entomologists of some of the dominions and colonies in 1912, a scheme for imperial co-operation in preventing the spread and furthering the investigation of noxious insects was worked out. This conference put forward a proposal for the establishment of an Imperial Bureau of Entomology, to be financially supported by the various dominions and colonies and the British government. The scheme was adopted by the various self-governing dominions and colonies which were invited to co-operate and contribute to the maintenance of the Bureau, and the crown colonies and British protectorates are also participating in the advantages of the Imperial Bureau of Entomology which was established in 1913 with headquarters in London. The former Entomological Research Committee has become the Honorary Committee of Management on which committee the government entomologists of the dominions are also members. The Rt. Hon. Lewis Harcourt, former Secretary of State for the Colonies, is Chairman of the Committee and Dr. Guy A. K. Marshall is Director of the Bureau and Editor of its journals.

The functions of the Bureau are as follows:

1. The collection and co-ordination of information concerning the noxious insects of the world so that any British country may learn by enquiry what insect pests it is likely to import from other countries and the best methods of preventing their introduction and spread.

2. The authoritative identification of insects of economic importance submitted by the officials of the Departments of Agriculture and Public Health throughout the Empire.

3. The publication monthly of the *Review of Applied Entomology* in which concise summaries or abstracts are given of all the current literature which has a practical bearing on the investigation and control of noxious insects.

4. The investigation of blood-sucking insects, particularly in Africa. At present all the field staff are engaged in studying the bionomics of the various species of *Glossina*; the special object of their investigations is to endeavour to devise some practical means of reducing the numbers of or eradicating these

carriers of the different types of *Trypanosomes*. The men engaged in this work are Mr. W. F. Fiske and Dr. G. D. H. Carpenter, in Uganda, Dr. W. A. Lamborn in Nyasaland and Dr. J. J. Simpson in the Gold Coast.

The work of the Bureau is wholly different from that of the United States Bureau of Entomology. Its primary function is that of an intelligence bureau, a clearing house for entomological information, collecting such information for the use of the British countries supporting it. It has already accomplished a large amount of useful work and has been of particular assistance to those isolated and scattered British territories where the entomologists and medical officers suffer from lack of museums, libraries and co-workers which they would wish to consult. International as the scope of its survey necessarily is, it has already demonstrated how valuable a similar Bureau properly constituted on international lines might prove.

England. The British Government in the past has not maintained an official entomologist or entomological staff. The Board of Agriculture and Fisheries has been content to retain the services of an outside entomologist to prepare replies to any entomological inquiries submitted to it by farmers and others, and their leaflets have been chiefly the work of unofficial advisers. In the absence of an official entomological staff the investigation of insects affecting agriculture has been left in the hands of men such as Prof. F. V. Theobald of the South Eastern Agricultural College who is now making a much needed study of the British aphides and whose work on mosquitoes is well known, Mr. C. Warburton of Cambridge, Prof. Newstead of Liverpool, Mr. W. E. Collinge, and others.

It is perhaps difficult on this continent to understand the underlying reason for the scant development of "official" entomology in England. But it must be pointed out that agricultural conditions are entirely different in such old countries where there is a more intensive system of farming, a consequent closer supervision of crops, cleaner cultivation and long developed systems of rotation. More especially, the comparative stability of the agricultural conditions has produced a more perfect balance in all those natural conditions the disturbance of which in more lately developed countries leads to an abnormal behaviour of the insects which are potentially noxious. These facts should, therefore, be borne in mind

in considering the apparent lack of any extensive development in applied entomology in the older European countries.

In 1912 the Horticultural Branch of the Board of Agriculture and Fisheries was established under the direction of Mr. A. G. L. Rogers. This branch has the administration of the Destructive Insects and Pests Act to carry out which legislation five trained inspectors are employed. Their work, however, is at present largely concerned with plant diseases. An advance was made in 1913 when Mr. J. C. Fryer was appointed Entomologist to the Board. His work is primarily of an advisory character, advisory to the Board in regard to legislation and to the public by means of letters or leaflets. He also studies epidemic pests and insects of unusual importance. For example, Mr. Fryer has begun a study of the species of *Hypnomenuta* the Ermine Moths, whose introduction into the State of New York afforded Mr. P. J. Parrott an opportunity of studying them in a new environment. The Narcissus Flies, *Merodon equestris* and *Eumerus strigatus* have also been studied. Mr. Fryer informs me that he is now studying *Hylemyia coarctata* a serious wheat pest in low-lying marshy districts. Capsid bugs, which cause similar injuries to fruit to those with which we are familiar in the northeastern region of North America, are also receiving attention.

Entomological investigations are also conducted at certain of the universities by means of grants from a Government Development Commission Fund. It would appear to be the intention to foster the investigation of insect pests in recognised university departments rather than in a department of the government, a plan which has advantages and disadvantages which I will not discuss here. As a result there is a Department of Agricultural Entomology at the University of Manchester under Dr. A. D. Imms, and forest insects are studied at the University of Oxford. Prof. Maxwell Lefroy of the Imperial College of Science and Technology, London, has also been conducting investigations in applied entomology.

Scotland. A few years ago a separate Board of Agriculture for Scotland was established and Dr. R. Stewart McDougall of the University of Edinburgh acts as Entomologist to the Board. Dr. McDougall's work is largely concerned with forest insects but his work on the Sheep Maggot Flies, *Lucilia* spp., is well known.

Ireland. Prof. G. H. Carpenter of the Royal College of Science, Dublin, acts as Entomologist to the Department of Agriculture and Technical Instruction of Ireland and publishes an annual report on economic entomology in the Proceedings of the Royal Dublin Society. Prof. Carpenter's investigatory work during a number of years has been confined chiefly to the study of the Warble Flies, *Hypoderma bovis* and *H. lineata*.

AFRICA.

On no other continent in the world has the struggle between insect and man been so acute as on this immense area containing tropical and sub-tropical conditions, and nowhere has the insect been so victorious or so securely entrenched in regions offering every advantage to it and every obstacle to man. The mosquito has held the key to some of the richest regions of the earth's surface, the Tsetse fly has rendered extensive transportation impossible, and the tick, if one may be permitted to use entomology in its broad sense and include ticks, has kept the white man at bay and devastated his herds. But by slow degrees the power is passing from insect to man and nowhere is the conquest of such an adverse and powerful force of nature by patient effort illustrated more strikingly than in the gradual conquest, in the real sense, of Africa. The West Coast is no longer a "White man's grave," as it was formerly called, nagana and tick fevers are losing their original terrors and we should be unworthy of our traditions did we believe that sleeping sickness would always remain the scourge that experience has demonstrated it to be within recent years.

The British territories in Africa are so situated that it has fallen to the lot of our investigators to contribute largely to this notable conquest, the history of which would constitute one of the finest examples of entomological achievement that we have. But to attempt to outline such a history would exceed the limits which must necessarily be set to this account of the manner in which the work is being carried on at the present time.

The Union of South Africa. Prior to the formation of the Union of South Africa the four colonies, Cape Colony, Natal, Transvaal and the Orange Free State, carried on their entomological work independently. Cape Colony which created a Division of Entomology with Mr. C. P. Lounsbury as Chief in 1895, was the most advanced. Following the union, Mr.

Lounsbury was made Chief of the new Division of Entomology of the Union Department of Agriculture with headquarters at Pretoria. The work of this Division comprises, in addition to the dissemination of advice on insect problems and the carrying on of investigations, the administration of government regulations concerning (1) the suppression of locusts, (2) the inspection of nurseries (3) plant and fruit imports, and (4) restrictions on the conveyance of plants and fruit. At Pretoria Mr. Lounsbury has Mr. Claude Fuller, former Entomologist for Natal, as Assistant Chief and is also assisted by Mr. D. Gunn and several inspectors. The following branch laboratories are also maintained: Capetown, with Mr. C. W. Mally in charge; Bloemfontein, Mr. J. C. Faure in charge of investigations in the Orange River Colony; and New Hanover, Natal, with Mr. C. B. Hardenberg in charge. In addition to the staffs at these laboratories, plant inspectors are stationed at the following ports of entry for plants and fruit: Capetown, Johannesburg, Durban, East London and Port Elizabeth. The agricultural situation in South Africa is peculiar owing to the fact that agriculture is not yet the basic industry of the country. The greater part of the agricultural lands is devoted to live stock, and the cultivation of the land is proceeding gradually. Nevertheless, the climatic conditions are eminently suitable to the cultivation of deciduous and citrus fruits with the result that progress in this direction is being made.

The development of a fruit-growing industry has naturally demanded a vigilant policy in the matter of preventing the introduction and spread of foreign fruit pests and the policy has been to restrict importations of nursery stock and to foster local nurseries. On this account nursery inspection constitutes the prominent feature of the work of the Division of Entomology. This work and the inspection of imported nursery stock and fruits and regulation of the transportation of home grown fruit is carried out under the Agricultural Pests Act of 1911.

To retard the spread of the codling moth which was introduced into the country, apple, pear and quince fruits may not be transported into certain areas. Equally stringent measures were adopted to prevent the spread of San Jose scale (*Aspidiotus perniciosus*). Undoubtedly the control of locusts constitutes one of the most serious problems in South Africa. Of the two species of migratory locusts the brown

locust *Pachytilus sulcicollis* is more serious than *Schistocerca peregrina*. From the Kalahari Desert, in what has hitherto been called German South West Africa, which is the permanent habitat of the species, vast swarms migrate to Central and Eastern Cape Colony, Transvaal, Orange River Colony and Rhodesia and breed there. These swarms sometimes have a frontage of fifteen to twenty miles and a length of sixty to seventy miles and take several days to pass a given point. They devastate the veldt of all green food with serious results; in 1906 it was estimated that the locust damage in South Africa amounted to five million dollars. The control of these locusts is regulated by law. Farmers are required to report the laying of the eggs and the appearance of the young hoppers. They are also required to destroy the young hoppers and the government furnishes the poison. Arsenite of soda mixed with water and molasses or sugar is universally used and with success over large areas, the poison being usually applied by means of bucket pumps which are loaned to the farmers. This campaign necessitates the keeping in stock of a large store of prepared poison and a supply of pumps for any emergency.

Notwithstanding the large amount of administrative work, the entomologists in South Africa have undertaken important lines of investigation. Mr. Lounsbury's work on ticks is well known and Mr. C. W. Mally's name will always be remembered where poisoned baits for fruit-flies are used. Mr. Fuller has also contributed to our knowledge of the termites and Mr. Hardenberg has made extensive studies of the insects affecting the wattle.

The tick problem is a very serious one in South Africa, several most important diseases of live stock being transmitted by these agents. Of these diseases East Coast Fever, due to the protozoan parasite *Theileria parva*, which is carried by several species of ticks of the genus *Rhipicephalus*, is the most serious and has played great havoc. In addition the disease included under the general term Piroplasmosis namely, bilary fever in horses and redwater in cattle, are serious adverse factors in the main type of agriculture followed in South Africa. Fortunately the Veterinary Branch of the Department of Agriculture has attacked the tick problem in a vigorous manner along well known lines, no little credit being due to the work of Dr. Arnold Theiler.

Rhodesia. The entomological problems of Rhodesia are not very dissimilar on the whole to those of South Africa, although there are certain lines of inquiry which are peculiar to this region. Mr. R. W. Jack, the Government Entomologist has his headquarters at Salisbury and is assisted by Mr. R. L. Thompson. Their work follows along the usual lines outlined in the case of South Africa. Under the "Importation of Plants Regulations" and "Nurseries Ordinance" the Government prevents the introduction and spread of insect pests and plant diseases. Four ports of entry have been established, namely, Salisbury, Bulawayo, Umtali and Gwelo, at which fumigation houses are maintained. Nurseries must register and are inspected annually.

The country is subject to locust plagues and native commissioners, cattle inspectors and members of the British South African police are required to report with full details any swarms, for the control of which locust poison, spray pumps, etc., are kept on hand. The Government protects the chief bird enemies of the locust, such as the White Stork, Cattle Egret, Lesser Locust Bird and Wattled Starling.

Much attention has been devoted by Mr. Jack to the study of Tse-tse flies and each year he devotes a portion of his time to travelling through the "fly" belts for the purpose of making bionomical investigations and delimiting the areas of these belts. Areas infested with *Glossina morsitans* are defined by government regulations and adjacent areas, or "open areas" are also defined in which the destruction of all game, with the exception of ostriches and certain game birds, is permitted. The results of Mr. Jack's investigations have been published in the *Bulletin of Entomological Research*.

Other investigations are mainly concerned with pests of the more important crops, such as corn (maize), citrus fruits and tobacco and with the pests of lesser cereals, field crops, vegetables and stone fruits. The wide range of plants and trees cultivated on the high and low parts of the territory offer an unusual broad field for research. Tenebrionids are very common and have been studied and also pests of corn (maize). A formidable problem is afforded by certain fruit-piercing moths belonging to the genera *Maenas*, *Ophiusa*, *Achaea* and *Sphingomorpha*, which severely injure practically all fruits.

The control measures are not specially peculiar, although where cheap coloured labour is available hand-picking may be more commonly used than in other countries dependent upon white labour. A long dry season enables advantage to be taken of clean cultivation. Owing to the fact that the country is being opened up by a keen class of agriculturists who are experimenting with new crops and are not bound by the hard and fast traditions of old farming communities, the entomologists are frequently consulted and co-operation in experimental work is readily secured.

Uganda. In this rich tropical country offering great opportunities for entomological investigations, Mr. C. C. Gowdy carries on his work as Government Entomologist single-handed. The study of the Tse-tse fly problem is not carried on by the Department of Agriculture, but independently of this Department, as I shall show later. Mr. Gowdy is stationed at Kampala and the size of the country and methods of travel, namely, by the use of porters, do not permit of a very thorough study of any one problem, especially as his only assistants are natives, who are constitutionally lazy, but nevertheless make good collectors.

The importation of plants and seeds is regulated by Government Ordinances. There is a single port of entry, Kampala, and there all imported plants are inspected and, if necessary, fumigated. The importation of cotton seed is prohibited; all plants from Ceylon, coffee plants and coffee other than roasted beans and ground coffee, are prohibited without special consent. A Plant Pest Board has been created, one of its objects being to facilitate the reporting of the existence of pests and the enforcement of preventive or remedial measures.

The chief entomological problems relating to agriculture in Uganda are connected with principle crops, namely, cotton, coffee, cacao and Para rubber. Termites and locusts also demand attention.

Undoubtedly the most serious entomological problem in Uganda at the present time is the suppression of sleeping sickness by the control of the Tse-tse fly. For about thirteen years this disease, which in the earlier part of the last decade was responsible for the deaths of several hundred thousands of the inhabitants of Uganda, has been studied at Entebbe by the

Sleeping Sickness Commission, on which Sir David Bruce has been the principal worker. The entomological aspect of the question was not specially studied until comparatively recently, but now it is receiving more of the attention it deserves, and I have referred to the fact that the Imperial Bureau of Entomology has two investigators at work in Uganda, namely, Mr. W. F. Fiske, formerly of the United States Bureau of Entomology, and Dr. G. D. H. Carpenter, who have already added substantially to our knowledge of the bionomics of the Tse-tse flies. In the adjacent British territory of Nyasaland, Dr. W. A. Lamborn of the Imperial Bureau of Entomology is studying the Tse-tse fly problem.

British East Africa. The Department of Agriculture has as its Chief Entomologist Mr. T. J. Anderson, who is stationed at Nairobi, the headquarters of the government of the Protectorate. He has an assistant, a Plant Import Inspector and a staff of native collectors. The careful examination of all plants, seeds, etc., entering the Protectorate is undertaken by the Plant Import Inspector under the Regulations of the Disease of Plants Prevention Ordinance, 1910. There are special regulations relating to coffee and cotton. Facilities are provided at the Government Experimental Farm where the entomological laboratory is situated for the carrying on of entomological investigations. The most troublesome insect pest perhaps is the coconut beetle (*Oryctes monoceros*). The antestia bug (*Antestia variegata*) is very injurious to the coffee plants. Experiments are now being carried out on the control of the latter pest by an Ichneumon parasite.

Egypt. Previous to the creation of a Department of Agriculture in 1910, the Ministry of Interior and the Khedivial Society of Agriculture undertook the study of insect pests, Mr. F. C. Willcocks being the Entomologist of the Society and the Yearbooks of the Society contain the results of his numerous investigations, particularly on the Egyptian cotton worm (*Prodenia litura*) and the Egyptian cotton boll-worm (*Earias insulana*). Insects affecting cotton have received the greatest attention on account of the increasing importance of that crop. Under the Ministry of Agriculture which was organized in 1913, the cotton worm, boll worm and locust campaigns are carried out by the Administrative Division independently of

the Entomological Section. The Entomological Section is part of the Technical Division of the Ministry of Agriculture. The Consulting Agriculturist, Mr. G. C. Dudgeon, who is also an entomologist, is head of the Technical Division. The Director of the Entomological Section is Dr. Lewis H. Gough, who is assisted by Messrs. G. Storey and E. W. Adair. In addition a staff of Egyptians under Dr. Gough's direction has charge of the inspection and fumigation of imported plants, which are treated at the port of entry. The fumigation of citrus trees, with a view to controlling *Aspidiotus aonidium*, which is a severe pest of oranges in the Delta region, is carried on by the Government fumigation brigades. Among the tropical fruit pests may be mentioned the pyralid moth *Ephestia cautella*, which seriously injures dates in some sections, and the butterfly *Virachola livia*, which attacks pomegranites.

In Egypt one meets in a striking manner the difficulties which confront the entomologist who has to deal in tropical countries with native agricultural labourers. These difficulties necessitate the control of insects, as far as possible, without the use of poisons or spray pumps. The native agricultural labourer is very ignorant and very careless and cannot be entrusted with poisons or with machines that are not entirely fool-proof. This accounts for the manner in which the annual campaign against the pests of cotton, the cotton worm and the boll worm is conducted by the Administrative Division. The regulations governing these campaigns provide for the hand-picking of the egg masses of *Prodenia litura* on the cotton leaves, and the reduction of the numbers of the boll worms is attempted by ordering and enforcing the destruction of all cotton bolls at a certain date each year after the final picking. Incidentally, it may be mentioned that persons who have been imprisoned for contravening the cotton worm laws are condemned to carry out these control measures. The pink boll worm of cotton *Gelechia gossypiella* was introduced into Egypt a few years ago with disastrous results, and methods for the control of the *Gelechia* larvae in cotton seed on a commercial scale are now being investigated; at present the treatment of seed, the destruction during the winter of cotton sticks and wood stored for fuel is required by law.

Reference should also be made to the work in Egypt of Mr. A. Andres, one of the inventors of the Andres-Maire bait traps for moths, to which reference is made in discussing the control of insects in India.

Sudan. The entomological work for this country is carried on by Mr. H. H. King, who is Entomologist to the Gordon Memorial College at Khartoum, the seat of Government. Mr. King's work has been largely confined to the study of the blood-sucking insects which are naturally of paramount importance in that region and his investigations on mosquitoes, and particularly on Tabanidae are furnishing valuable results.

In passing attention should be called to regulations governing the examination of persons entering the Sudan from Uganda for sleeping sickness. Such persons must proceed to Mongalla for examination by the Medical Officer there. There are also restrictions on trade with Uganda; it may only be carried on by licensed persons.

Locust outbreaks constitute a serious trouble from time to time in the Sudan, *S. perigrina* being the chief species and the use of poisoned bait, poisoned with sodium arsenite has been employed with success.

British West Africa. The British territories consist of the colonies of Gambia, Sierra Leone, the Gold Coast, Lagos, and Northern and Southern Nigeria. In these rich tropical regions the agricultural products are very varied, including not only such native products as rubber, palm oil, cacao and various native nuts, etc., but cultivated crops such as cotton, the development of which industry is progressing, rice, coffee, and corn (maize). The greatest obstacle to agricultural development under European direction has been the widespread occurrence of malaria, which for many years rendered permanent residence impossible to Europeans. To a lesser degree other tropical diseases contributed to the difficulties of existence and agricultural expansion. Fortunately, it has been possible in recent years by the adoption of the necessary anti-malarial measures to remove to an encouraging degree so serious an obstacle, with consequent impetus to the development of those rich territories.

The development of entomological work, in so far as it relates to the study and control of insect pests affecting the

crops that are grown, has naturally been seriously handicapped by hitherto well nigh insuperable factors. Nevertheless, much pioneer work has been accomplished and a considerable amount of information has been collected regarding the insect pests occurring in the various territories. Mr. A. D. Peacock, late Entomologist for Southern Nigeria, has published an extensive report on the insect pests of that region and Mr. W. H. Patterson on the Gold Coast and Mr. A. W. Jobbins-Pomeroy in Nigeria, are prosecuting their investigations with a zeal that is not checked by the primitive and backward conditions of native agriculture, the difficulties of travel or the inadequacy of laboratory accommodation, assistance or entomological equipment. To those entomologists brought up and accustomed to work in the lap of luxury so far as facilities and apparatus for entomological investigations are concerned, the difficulties with which the British entomologists working in these tropical colonies have to contend are inconceivable. That they are able to accomplish so much is proof of their intense enthusiasm for their work and their ability to withstand conditions and surmount obstacles which would conquer any but the strongest natures.

The widespread prevalence of tropical diseases, particularly malaria and human Trypanosomiasis, led the Imperial Bureau of Entomology to undertake extensive surveys of the distribution of the blood-sucking insects of West Africa and Dr. J. J. Simpson has been conducting such an investigation. He has collected an enormous amount of valuable data and has made observations of great importance as a perusal of his numerous excellent reports which have been published in the *Bulletin of Entomological Research* will show. His investigations which are being continued at the present time constitute one of the most important phases of the Imperial Bureau's work.

AUSTRALIA.

A visitor to Australia is impressed with the abundance of insect life, particularly in the tropical and sub-tropical regions of the continent and, while little more than the fringe of the possible agricultural regions of the country has been utilized, if we except the sheep grazing sections, where production of deciduous and citrus fruits and sugar is being actively developed, the inevitable disturbance of the natural equilibrium and the

introduction of new pests before quarantine restrictions are imposed, has followed. Fortunately, the continent appears to be well supplied with natural means of control of a vigorous kind, particularly as regards predatory insects such as ants and coccinellids, in fact Australia has always been the happy hunting ground for the lady-bird hunters.

The Commonwealth Government of Australia did not on its formation about fifteen years ago, assume any jurisdiction over agricultural matters, but left the individual states in full control. There is, therefore, no entomological work undertaken by the Commonwealth Government beyond the administration of the Federal Quarantine Act, which regulates the importation of plants, etc., into the country; this Act, I believe, is administered by the Department of Trade and Custom. As the entomological work is carried on by the various States independently it must be so described.

New South Wales. Agriculture is one of the principal industries of the State, the largest area being devoted to sheep grazing. Cereals, corn, tobacco, deciduous and citrus fruits and sugar cane are also grown successfully. Consequently the range of insect pests encountered in the State is extensive. The work of Mr. Walter W. Froggatt, the Government Entomologist is well-known. While his sphere is New South Wales, he carries on extensive correspondence with other parts of Australia, with New Guinea, Fiji and other islands of the Pacific. His experimental work is carried on at the various Experiment Farms in the State and at a small station at Narara experiments on the control of fruit flies, which constitute perhaps the worst insect pest on the continent, are conducted. Owing to the serious losses inflicted by various species of blow-flies of the genus *Calliphora* on the sheep industry a special field station has been maintained for several seasons for the investigation of sheep maggot flies.

Under the State Vine and Vegetation diseases Act a large staff of inspectors is employed in different districts to see that the regulations concerning spraying, etc., are carried out. Imported fresh and dried fruits, seeds, etc., are subject to inspection and exported fruit is fumigated if required. An unusual line of work consists in the certification of freedom from the fowl tick (*Argas persicae*) of all the poultry going out of the State.

Under the direction of Dr. Frank Tidswell, Director of the Government Bureau of Microbiology, attention has been paid to insects concerned in the transmission of disease, particularly by Dr. J. B. Cleland, the results of whose investigations have been published in the Annual Reports of the Bureau.

Victoria. Agriculture in the State is of a general character, the area under cultivation, particularly in cereals, is increasing. Mr. C. French, Jr., is responsible for the entomological work, but little work of an investigatory character appears to be carried on. A large part of Mr. French's time is devoted to the administration of the Fruit and Nursery Inspection ordinances.

South Australia. About two thirds of the area of the State are farmed or grazed. The climate permits the growing of citrus fruits, almonds and olives and there is a considerable acreage under vineyards. The entomological work of the State is carried on by the Horticultural Division of the State Department of Agriculture at Adelaide. Strict measures are employed to prevent the introduction of the grape phylloxera and of other exotic insect pests by the usual methods of fumigation, etc. Nursery inspectors are also employed to carry on a campaign against the codling moth and scale insects affecting fruit.

Queensland. The State Department of Agriculture has maintained an Entomologist since 1897 and the name of the Government Entomologist, Mr. Henry Tryon, who has his headquarters at Brisbane, is known to most entomologists. The varied climatic conditions of the State permit the existence of an extensive range of insect pests, affecting in addition to the usual agricultural crops and fruits, such tropical and sub-tropical crops as cotton, sugar, pineapples, bananas, coconuts and coffee. Mr. Tryon has recently returned from a world's tour taken for the purpose of investigating the methods by which the prickly pear may be destroyed. Much of the Entomologist's time is occupied in travelling about the State. Insects affecting sugar cane receive, perhaps, the most attention, a special field station for their investigation being maintained at Gordonvale, near Cairns. In the sugar-cane growing district Grub Pest Destruction Committees exist for the purpose of encouraging the destruction of sugar-cane insects, particularly the beetle *Lepidoderma albohurtum*.

Imported and exported fruits and fruit grown and sold in the State are inspected under State regulations by a staff of inspectors and the inspection of nurseries is also carried out.

The existence of insect borne diseases in the State has resulted in attention being paid to this branch of entomology and at the Tropical School of Medicine at Townsville Mr. F. Taylor has carried on some excellent work on blood-sucking Diptera, particularly *Culicidae* and *Tabanidae*.

Tasmania. The entomological work of the Island State is conducted in conjunction with the phytopathological work and advice on the control of insect pests is also given by the Fruit Expert. Imported fruit is inspected and local Fruit Boards administer the provisions of the Codling Moth Act.

Western Australia. The agricultural productions of this State whose cultivated lands fringe the western coast of the continent consist mainly of cereals, fruit and wines. Large areas suitable for the cultivation of the vine, olive and silk could be opened up if labour and means of transport were procurable. An Entomologist has been maintained since 1898 and the present occupant of the position is Mr. J. L. Norman, with headquarters at Perth. An inspection service is maintained for the supervision of imported vegetation and the nurseries in this State, and modern methods of dealing with insect pests affecting fruit are very generally followed.

Northern Territory. Little work on economic insects has been carried out in the State owing no doubt to the lack of agricultural development. But the Government Entomologist, Mr. Gerald F. Hill, who is stationed at Darwin, has made some valuable and interesting contributions to our knowledge of the Termites. Recently he has been studying the relation of blood-sucking flies to the transmission of parasitic nematode worms, and he will no doubt have excellent opportunities for further work on veterinary and medical entomology.

CANADA.

The interest in each other's work and the spirit of co-operation that exists between Canada and the United States renders an enumeration of our entomological problems unnecessary, for owing to the fact that we share the same continental area without any barrier greater than a parallel of latitude and a

few rivers and lakes we are compelled to experience many of your entomological troubles and to receive the generous overflow your hospitality to foreign invaders provides. But while we may have to study the control of the same insects that occur in the United States, it does not necessarily follow that our methods will be the same. In many cases the environmental conditions in Canada, particularly in the matter of climate, are different with a resultant difference in insect behaviour and therefore in control. Accordingly, in our entomological work we are taking nothing for granted, except where we are compelled, but we are working out our own problems *de novo*.

While applied entomology was officially recognized in Canada as early as 1856 it did not have its real birth until 1869, six years after the establishment of the Canadian Entomological Society, now the Entomological Society of Ontario by reason of a provincial grant and charter. The recognition and support of this Society by the Province of Ontario constituted the only official step in applied entomology until the appointment of Dr. James Fletcher by the Dominion Government in 1884 as Government Entomologist. The Dominion Experimental Farms were established in 1886 and to this Branch of the Department Dr. Fletcher was attached as Entomologist and Botanist until his death in 1908. A separate Division of Entomology of the Experimental Farms Branch was then created and I was entrusted with the organization on my appointment in 1909 as Dominion Entomologist. In 1910 the Destructive Insect and Pest Act was passed and in 1911 the first Dominion Field Laboratory was established; these two facts are indicative of the two chief lines of the Dominion work—administrative and investigatory—and the development of the work along these special lines led in 1914 to the separation of the entomological service from the Experimental Farms Branch and its elevation to the status of an independent Branch of the Department of Agriculture. The sanction of the Dominion Parliament to increased appropriations which are now more in accord with the needs of the country is encouraging evidence of a desire to afford the means whereby the entomological service of the Dominion shall be in a better position to meet the requirements of the situation.

We have now nine field laboratories and two sub-stations. The laboratory at Annapolis Royal, N. S., serves as headquarters for the control work and bionomical studies of the brown-tail moth. Mr. G. E. Sanders, the officer in charge, is also investigating the bud-moths and green-fruit worms of apple and their control and is conducting insecticidal investigations. A sub-station is situated at Bridgetown, N. S., at present.

A new and commodious laboratory building in Fredericton, N. B., serves as headquarters for the work in New Brunswick, of which Mr. J. D. Tothill and Mr. L. S. McLaine have charge. Mr. Tothill is in charge of the colonization of the parasites and predatory enemies of the brown-tail and gipsy moths which enemies, through the courteous co-operation of Dr. L. O. Howard, Chief of the United States Bureau of Entomology, we are collecting and importing from the New England States. In addition Mr. Tothill is conducting an intensive study of the natural control of three of our widely spread and periodically destructive insects—the tent caterpillar (*Malacosoma disstria*) the spruce budworm (*Harmologa fumiferana*) and the fall webworm (*Hyphantria cunea*). It is our intention to continue this study over a number of years. The results secured during the past two or three years have indicated the value and necessity of such an intensive study. Mr. McLaine has charge of the field work against the brown-tail moth in the winter on which a force of seventeen to twenty inspectors is engaged, and in the summer he is stationed with two assistants at the Gipsy Moth Laboratory, Melrose Highlands, Mass., in connection with the breeding of the parasites of the brown-tail and gipsy moths.

At a field laboratory situated at Hemmingford, Quebec, a little south of Montreal, Mr. C. E. Petch is investigating the apple and plum curculios, and other insects affecting apple in connection with which experimental and demonstrative work on spraying is conducted in a number of orchards. Mr. Petch has also been carrying on experiments for three seasons on the control of locusts by means of the *Coccobacillus acridiorum*.

There are two Field Laboratories in Ontario. At Vineland in the Niagara fruit district, Mr. W. A. Ross is in charge of a laboratory where fruit insect investigations are mainly carried on. For four seasons Mr. Ross has been studying the control of the apple maggot (*Rhagoletis pomonella*). Two years ago

he commenced an investigation of the aphids affecting apple: *Aphis sorbi*, *A. pomi* and *A. avenæ*, which are very injurious. Greenhouse and mill-infesting insects are also studied at this laboratory. At a laboratory at Strathroy, Ont., in the western part of the province, Mr. H. F. Hudson, who is at present on leave in Flanders, has investigated the chinch bug (*Blissus leucopterus*) and commenced a study of the white grubs (*Lachnosterna* spp.) which investigation is being continued in his absence by Mr. J. R. Gareau.

Our next Field Laboratory is situated at Treesbank in southern Manitoba and here Mr. Norman Criddle, whose work on locust control is well known, is investigating the bionomics and control of white grubs (*Lachnosterna* spp.) and in this connection I should mention that this investigation is complementary to that now being conducted by the United States Bureau of Entomology, the intention being to study these insects over the whole range of their distribution in North America. The value of such co-operative inquiry is obvious to all. In addition Mr. Criddle is investigating the insects affecting cereals and the results of his studies of the Hessian fly and the wheat-stem sawfly have been recently published.

The prairie region is also served by a laboratory at Lethbridge in southern Alberta where Mr. E. H. Strickland has been devoting particular attention to a study of the various species of cutworms which are seriously injurious to grain and other crops periodically. For example, in 1912 *Porosagrotis orthogonia* destroyed about 35,000 acres of wheat. Last year the Army Cutworm (*Chorizagrotis auxiliaris*) was studied and control measures were demonstrated in the field with valuable results. Mr. Strickland has also been investigating the abundant nematode fauna associated with growing grain.

The headquarters for our work in British Columbia are at Agassiz in the lower valley of the Frazer River. Mr. R. C. Treherne, the officer in charge, has been investigating both fruit insects and insects affecting vegetable crops. The results of his study of the strawberry root weevil (*Otiorynchus ovatus*) were published some time ago and his investigations on the cabbage root maggots are now completed. In addition he has made valuable observations as a base for further study, on the wheat midge (*Diplosis ? tritici*) and the budmoth of apple and other apple insects.

At Vancouver, B. C., we have a laboratory for forest insect investigations. Mr. R. N. Chrystal, the field officer in charge, has been studying in particular the insects destroying conifers in Stanley Park, especially species of *Chermes* and one or two lepidopterous larvæ. Under the direction of Mr. Swaine he has continued the latter's observations on the *Scolytidæ* and other timber destroying beetles in the province.

All the work is directed from Ottawa where the offices of the Entomological Branch are situated. Mr. Arthur Gibson is Chief Assistant Entomologist and in addition to assisting in the regular executive work of the Branch and the administration of the provisions of the Destructive Insect and Pest Act, he has charge of the work on insects affecting field crops, garden and greenhouse and stored products. Mr. Gibson's work on the Noctuidæ is well known and during the last few years he has been investigating chiefly the control of locusts and root maggots. Mr. J. M. Swaine is Assistant Entomologist in charge of Forest Insect Investigations. The extensive coniferous forests of Canada naturally offer great opportunities for such investigatory work and particular attention has been paid to serious and widespread injuries by Scolytid beetles in British Columbia. For a number of years Mr. Swaine has been making taxonomic and biological studies of the *Scolytidæ* and we hope to commence the publication of the results of this study shortly. Our studies of the spruce budworm, exclusive of its natural control, have been completed and in addition much ground work has been accomplished in the study of insects affecting shade trees. Mr. Germain Beaulieu has charge of the collections and the recent establishment of a national collection of insects has enabled us to give this aspect of our work the recognition it deserves.

The Dominion work of preventing the introduction and spread of injurious insects is carried on under the Destructive Insect and Pest Act, 1910. Under the Regulations of this Act the importation of all nursery stock, etc., is governed. Nursery stock may be imported only during certain periods through prescribed ports of entry at which fumigation and inspection stations are provided. Importers are required to give notice of the ordering and receipt of those classes of trees and plants subject to inspection. Quarantine regulations also prohibit

the importation of certain classes of nursery stock and vegetable products, for example, the importation of conifers and evergreens from the New England States is prohibited on account of the gipsy moth, of potatoes from California on account of the potato tuber moth (*Phthorimaea operculella*), of non-canned fruit from the Hawaiian Islands on account of the Mediterranean fruit fly (*Ceratitis capitata*). The field work against the brown-tail moth in Nova Scotia and New Brunswick is also carried out under the regulations of this Act. Each winter the whole of the infested area in these two provinces is scouted and all the winter webs of the brown-tail moth are collected. This careful work has so far prevented the establishment of this insect in New Brunswick and has kept it from increasing beyond harmless proportions in Nova Scotia.

It would exceed the limits which must necessarily be set to an account of this nature if I permitted my enthusiasm to exceed my judgment and described further aspects of our work which are reported annually, although I am aware of the humiliating fate that annual reports not infrequently suffer.

Mention should be made of the valuable investigations that are being carried on at Agassiz, B. C., by Dr. Seymour Hadwen, Assistant Pathologist of the Health of Animals Branch of the Dominion Department of Agriculture, on the life histories of *Hypoderma bovis* and *H. lineata*, which are undoubtedly the most important hitherto carried out.

In certain of the provinces applied entomology has made encouraging progress, particularly during the last few years. In Ontario, in which province applied entomology in Canada had its birth, the Entomological Department of the Ontario Agricultural College at Guelph has always combined with its educational work the duty of assisting the farmers and fruit growers of the province in solving their problems and with this work and the earlier work in Canada the name of Dr. C. J. S. Bethune will always be associated. In 1912, Mr. Lawson Caesar, who is Associate Professor of Entomology in the Agricultural College, was appointed Provincial Entomologist. In addition to the investigatory work on insects affecting fruit, Prof. Caesar has charge of the inspection of nurseries in Ontario, which work is carried out under the provincial Fruit Pest Act.

British Columbia at present has no Provincial Entomologist owing to the removal of Mr. W. H. Brittain, the occupant of that position for one year, to Nova Scotia. Mr. Thomas Cunningham, the Provincial Inspector of Fruit Pests has charge of the work involved in administering the regulations of the Provincial Horticultural Board governing the control of insect pests and plant diseases. It is largely due to his zeal that the province is so remarkably free from such orchard pests as the San Jose scale and codling moth. The inspection of foreign nursery stock is carried out by a co-operative arrangement with the Dominion Department of Agriculture.

The Province of Nova Scotia appointed a Provincial Entomologist in 1912, Dr. R. Matheson being the first officer. He was succeeded in 1913 by Prof. W. H. Brittain, who is also Professor of Entomology in the provincial Agricultural College at Truro, N. S. In addition to administering the provincial Injurious Insect and Pest Act, and his teaching duties, Prof. Brittain has found time to initiate several important entomological inquiries. In particular may be mentioned investigations on the aphids affecting apple, the apple maggot and *Lygus invitus*. For the purpose of prosecuting this work two provincial field laboratories have been provided, one at Kentville N. S., and the other at Smith's Cove, N. S. All nursery stock entering the province is inspected and fumigated and the Dominion Department of Agriculture has agreed to the inspection and fumigation by the province of foreign nursery stock.

Since the establishment in the province of Quebec of the Macdonald Agricultural College at St. Annes in 1907, Prof. W. Lochhead and his staff have developed the study and practice of applied entomology in the province and at the present time entomological investigations are being conducted there. Much educational work is being accomplished through the Quebec Society for the Protection of Plants from Insect Pests and Fungous Diseases which receives a provincial grant. In 1912 the Abbe V. A. Huard, Curator of the Provincial Museum at Quebec, was appointed Provincial Entomologist and he administers a provincial act passed in 1913, providing for the inspection of nurseries in the province.

In the other provinces of Canada, no provincial entomologists have been appointed and where entomological investigations are being conducted they are in connection with one

or other of the Dominion Field Laboratories that I have mentioned. As the need for more work, particularly of a local character, develops, additional attention will no doubt be paid by the Provincial Departments of Agriculture to applied entomology. In the meantime they rely on the assistance provided by the Dominion Government. Where Dominion and provincial officers are carrying on investigations in the same province, the heartiest co-operation is enjoyed and arrangements are made with a view to preventing duplication of the work and consequent loss of energy. In certain cases investigations are conducted conjointly and this spirit of co-operation is most valuable, particularly in its relation to the attitude of the public towards the work.

CEYLON.

For a number of years Mr. E. E. Green, who is widely known by his work on the Scale Insects, was Government Entomologist to the Department of Agriculture of Ceylon and subsequent to his relinquishing the position in 1911, entomological work on this island was carried on by Mr. A. Rutherford whose recent untimely death was a great loss to colonial entomology. Mr. E. R. Speyer is now in Ceylon investigating the most serious insect pest of the island, namely, the shot-hole borer of tea *Xyleborus fornicatus*. Tea is also injured by the tea Tortrix, *Capua coffearia*, the yellow tea mite, *Tarsonemus translucens*, and the Termite, *Calotermes militaris*, which hollows out the stems of living tea bushes. Rubber in Ceylon is attacked by a number of insects, particularly root and other borers. Cocoa, rice and mulberry plants are subject to the attacks of a number of pests. Various species of Termites are injurious to woodwork as in most tropical countries where they occur.

Fiji.

When Mr. F. P. Jepson commenced his work as Entomologist to the Department of Agriculture of Fiji in 1909, he found serious problems awaiting his attention, particularly in the matter of insects affecting bananas and cocoanuts. On the island of Viti Levu coconut cultivation was practically abandoned many years ago, owing to the injury done to the leaves by a small moth *Levuana iridescens* B. B. Since 1912 a change

has taken place which renders the chances of combatting the insect successfully more hopeful. The most serious pest of the bananas in Fiji is the weevil *Cosmopolites sordidus* Germ.; as many as 100,000 individuals having been collected in one month on a single plantation. This widely distributed pest was introduced in 1901. As enemies in the form of predacious beetle larva occur in Java and Dutch Borneo, and in view of the impossibility of controlling the pest by artificial means, Mr. Jepson visited Java in 1913 to study the insect predators of this weevil and among them he found the Histerid beetle, *Plæsius javanus* Er., the most effective. Five thousand of these beetles were collected and three thousand seven hundred and ninety-two were successfully transported to Fiji where they were distributed in lots of 500 upon different badly infested banana plantations. Subsequent visits showed that the beetles were alive and reproducing after four months in the country and good results are expected from this interesting experiment, which indicates the progressive character of Mr. Jepson's work.

INDIA.

The control of insect pests in India is a subject of singular interest, not so much on account of the unusual nature of the insects which are encountered there but owing chiefly to the character of the cultivators, the nature of the country and the climatic conditions. Agriculture constitutes at present the chief industry of the country and about sixty-five per cent. of the people are dependent upon it as a means of livelihood. The European planter is practically negligible as a constituent factor, the dominant class being the cultivators. These are native Indians who live on the land and have had a very limited education. In many cases they have inherited a perfect system of agriculture. But in the face of an insect outbreak their preconceived notions of such calamities, their aversion to taking life directly and their lack of any kind of material equipment for fighting pests make the application of modern methods of insect control almost an impossibility. Prof. Maxwell Lefroy who did valuable work of a fundamental character in India, has described some of the prevalent ideas, he says: "An intelligent cultivator growing sugar-cane under irrigation on an extremely sound system with good manure, believes the cane-borer comes with the well-water used for irrigation." He has no conception

of its life history but he regards the whole thing as a mystery, not comparable with the life of any other animal; he will, as likely as not, call in a priest to check it; the priest will perhaps write four texts from holy writings, place them one at each corner of the field to confine the evil influence and then remove one to let out the influence which the texts have incommoded. Or, he will pay a man of a certain caste to plough a line across the field at night, the man having to be stark naked. In some parts locusts are believed to be the incarnation of a particular deity and for each one killed a hundred will come; it is quite likely that this has occurred, of which a few were killed being followed later by a much larger swarm, but where we see no connection, he sees a definite sequence of events. A case came up where a man freed his rice field of a pest by a simple mechanical method; his crop benefited but soon after his cow died, and to that village the one was a consequence of the other. It is difficult for entomologists in countries such as ours to realize the almost impossible task of overcoming such long inherited and deeply ingrained instincts and religious beliefs. These facts should be borne in mind in studying the methods employed. The use of insecticides is naturally enormously restricted as also is the employment of any but the simplest of mechanical devices. Largely for these reasons we find the necessity of resorting to such methods as the use of bait traps for moths and hand picking, the latter being rendered possible by the cheapness of the labor.

The losses from insects in so large a country are naturally great and in many instances the failure to grow staple crops in certain regions is undoubtedly due to an inherited tradition, resulting from uncontrolled insect outbreaks, that such crops cannot be grown. An outbreak of the cotton boll worm in the Punjab and Sind in 1906-07 caused a loss of about 2,000,000 pounds sterling. In the locust campaign of 1903-04, 14,000 pounds sterling was spent in destroying these insects in one province. The great Kirman Desert of Persia constitutes the chief central breeding place for the parent flights of *S. peregrinum*, entering India from the northwest.

In order to understand the organization of the work in applied entomology it is necessary to know the system of government. The government of India is the supreme authority,

the provinces into which the country is divided being under provincial departments such as Madras, Bombay, Central Province, Bengal, etc. The Imperial Department of Agriculture conducts investigations and advises and directs the work of the provincial departments. The latter largely carry into effect the recommendations of the Imperial experts as they do not all employ experts of their own, although a number of them now have native or European entomologists attached to their agricultural staffs.

The headquarters of the Imperial Entomologist are at the Imperial Research Laboratories at Pusa. Mr. T. Bainbrigge Fletcher is Imperial Entomologist and Mr. T. M. Howlett has charge of the work in medical and veterinary entomology. In addition to English assistants there is an excellent native staff. The scope of the work includes the investigation of the life histories and bionomics of insect pests and the most practicable methods of control under local conditions and experimental work with insecticides.

An important section of the entomological work has reference to useful or productive insects particularly sericulture and the production of lac. These constitute important industries in certain sections of India. For example, about three million pounds worth of lac is produced annually and whereas at present it is mainly a forest product, collected wild in the jungles, the entomologists have shown how it can be produced more cheaply by proper cultivation on trees growing on pastures and waste lands in agricultural tracts. Prof. Lefroy's work on Eri silk, produced by *Attacus ricini* of Assam, furnished a means whereby a new silk industry might be built up in certain localities in India.

Among the more important pests the following may be mentioned:

In certain regions swarms of hairy caterpillars, the larvæ of Arctiid moths, appear regularly after the first rain and cause great loss in grass lands, etc. It has been found that these insects can be largely controlled by capturing the adult moths in bait traps of the Andres-Maire pattern. In one region in Bengal about 10,000 acres of Tal land was destroyed annually for fifteen years by caterpillars of *Agrotis ypsilon*. It was found that hand picking of the larvæ and capture of the

moths by bait traps constituted the best control measures. In the bait traps eighty per cent. of the moths were unfertilized females. Serious damage to the rice crop is caused by the rice grasshopper (*Illieroglyphus furcifer*). For the control of this insect coarse bags are used, the bags being kept open by two bamboos as they are drawn through the rice which of course is grown in water; two beaters go before the bag and drive the grasshoppers towards or with it. Cotton is attacked by two boll-worms and a *Gelechia*; the boll-worm is a serious bar to the growth in India of any but the short stapled cottons which mature rapidly and offer little scope for boll-worm injury. In the control of the boll-worm in the Punjab, success appears to have attended the use of parasites.

The immense loss of life due to insect-borne diseases, especially to malaria in India is well known and the importance of the work carried out by Mr. Howlett in conjunction with the Imperial Medical and Veterinary Departments needs no emphasizing. Entomologists and medical men in India have had no small share in the advancement of our knowledge of medical entomology from the time when Ross carried out his crucial investigations up to the present time and the standard and scope of the work in India is steadily increasing year by year through the labors of men such as Dr. W. S. Patton, F. W. Cragg and others.

The condition of India in regard to that problem, which is of such vital concern to more temperate regions and regions in which agricultural development is taking place, such as the United States and Canada, namely, the introduction and establishment of foreign insect pests is peculiar and full of interest from a biological standpoint. The fact that India has not taken in years past any special steps to prevent the introduction of insect pests may appear strange to the minds of many accustomed to the necessity of such measures. The omission is not due to a failure to appreciate the importance of foreign pests, but to a distinct failure on the part of foreign pests to become acclimatised to Indian conditions. India appears to be protected far more effectively, and at considerably less cost, against foreign insect pests by her climate and topographical features. It is an isolated country bounded on the north by a vast non-agricultural territory from which it is separated by a

formidable mountain barrier. Prof. Lefroy informs us that in India fierce dry heat is the insect's enemy and the greatest check on insect life is that period before the rains when all is parched and very hot. These are powerful adverse factors to most foreign insects, although some, such as the cabbage white (*Pieris brassicae*) and the wheat aphid (*Toxoptera graminum*) have adapted themselves in different ways to the climatic conditions. A statement which Prof. Lefroy has given of the relative proportions of native and introduced insects indicates very clearly the evident check on the ability of foreign insects to become acclimatised to India. Of the crop pests, exclusive of scale insects and mealy bugs, out of 213 species injurious in some degree, two moths and six aphides are possible introductions. Out of 109 scale insects, 24 are probably introduced and of the most injurious ones, eleven out of the fourteen, are introduced; the introduced scale insects are comparatively harmless as a rule in India. These facts afford an interesting contrast to our experience in North America.

NEW ZEALAND.

The chief agricultural industry in New Zealand has been sheep farming. But with development along other lines, particularly in horticulture, the country has suffered the fate of all new countries dependent upon the importation of plants from foreign countries, and foreign pests have been introduced. At first these pests were not subjected to the methods that a later developed intensive system of agriculture involves and consequently they made some headway.

While the entomological work of the government is largely undertaken by the Government Biologist, Prof. T. W. Kirk, the question of the control of insect pests is also dealt with by the Fields and Experimental Farms Division and by the Orchards, Garden and Apiaries Division. The latter Division administers the inspection laws, involving the fumigation and inspection of imported fruits and plants and the spreading of useful insects. The Biological Section of the Department of Agriculture investigates, so far as its other duties permit, injurious insects in addition to conducting general identification work.

BRITISH WEST INDIES.

In 1898 the Imperial Department of Agriculture for the West Indies was established with headquarters at Barbados for the purpose of rendering assistance in agricultural matters throughout the British West Indies, including British Guiana, Trinidad, Jamaica, British Honduras, Bahamas, Bermuda, Barbados, the Windward Islands and the Leeward Islands. It is principally concerned, however, with the smaller islands, namely, those of the Windward and Leeward groups and Barbados. As the larger colonies British Guiana, Trinidad and Jamaica have organized departments of agriculture and being in a more prosperous condition, it is the function of the Imperial Department to advise the Government of these colonies. In the case of British Honduras, Bahamas and Bermuda, advice by correspondence is fully available.

Mr. H. A. Ballou succeeded Mr. H. M. Lefroy in 1903 as Entomologist on the staff of the Imperial Department and he carries on his work under the direction of the Commissioner of Agriculture, Dr. Francis Watts. In addition to the entomological work conducted by the Imperial Department, certain of the West Indian colonies maintain entomologists or combine the work with that on plant diseases. Mr. F. W. Urich is Entomologist to the Board of Agriculture for Trinidad and Tobago; Mr. G. E. Bodkin, as Economic Entomologist to the Department of Science and Agriculture of British Guiana, is responsible for the entomological work in that colony. Mr. A. H. Ritchie was appointed about a year ago as Entomologist to the Department of Agriculture for Jamaica. In Barbados the entomological work of the island is carried on by Mr. J. S. Dash, the Assistant Superintendent of the local Department of Agriculture, for although the Imperial Department of Agriculture has its headquarters in Barbados it has no direct connection with the agriculture of the colony.

The Entomologist of the Imperial Department of Agriculture Mr. Ballou, is directly concerned with the insect problems of the Windward Islands (Grenada, St. Vincent and St. Lucia) and the Leeward Islands (Dominica, Montserrat, Antigua, St. Kitts-Nevis and the Virgin Islands). He has a laboratory in the departmental building and on each island facilities for field work are provided by the local agricultural departments, each

of which has a botanic garden or experiment station, and the officers in charge of these gardens or stations assist in the local entomological work.

The chief lines of entomological investigation are associated with the principal crops grown on the islands, namely, sugar cane, cotton, cacao, limes and cocoanuts. A large number of new crops are being tried and these will naturally introduce new lines of entomological inquiry. The islands have suffered the fate of all new regions into which new crops have been introduced. The crops grown at present are practically the same as they were ten years ago, the principal difference being the standing of the cotton industry which was then in an experimental stage. Now it has been established as a profitable industry and as a result of the rapid increase in the acreage of cotton, insects which previously were not recognized as pests, and in some cases were unknown to science, have assumed an important role as serious pests. For example, the flower-bud maggot of cotton (*Contarinia gossypii* Felt) first made its appearance in Antigua in 1907; the leaf blister mite *Eriophyes gossypii* Banks, first occurred as a pest of cultivated cotton in Montserrat in 1903 and soon afterwards was found in all the other islands of the Leeward and Windward groups. The black scale (*Saissetia nigra* Nietn.) was formerly a serious pest of cotton, but at present it attracts little attention owing to the control brought about by the parasite (*Zalophothrix mirum*) which was first reared in 1907. Important injuries are caused by certain hemipterous cotton stainers of the genus *Dysdercus*, and a serious internal boll disease or rot now under investigation, occurring in certain islands appears to be associated with the attacks of these cotton stainers.

One of the most serious classes of injurious insects occurring in the West Indies, particularly in fields of sugar cane and corn (maize), are the Melolonthid larvæ known as white grubs on this Continent; these insects are popularly known as hard backs on the islands, the chief species being *Ligyrus tumulosus*. On certain of the islands recent investigation has shown that a noticeable control is exercised by several insect parasites of these larvæ. Among the control measures recommended are the planting of trap crops and hand picking the larvæ which measure cheap juvenile labor renders possible. Lepidopterous

and rhyncophorous borers, particularly such root borers as *Diaprepes abbreviatus* L. and *Exophthalmus esuriens* are serious pests of sugar cane. Termites are also injurious to sugar cane.

Citrus trees in the West Indies have their full share of scale insects, the purple scale (*Lepidosaphes beckii* Newm.) being the most important. A considerable degree of control is exercised over this and other scale insects by certain entomophagous fungi. The red-headed fungus (*Sphærostilbe coccophila*) and the white headed fungus (*Ophionectria coccicola*) attack the purple scale, the former fungus also attacks the white fly (*Aleyrodes citri* R. and H.) The green scale (*Coccus viridis* Green) is controlled to a marked degree by the shield scale fungus (*Cephalosporium lecanii*). In Trinidad the fungus *Metarrhizium anisoplae* has been artificially cultivated and used with a view to controlling frog-hoppers attacking sugar cane.

Naturally every effort is made to prevent the introduction of foreign pests into the islands by quarantine regulations. The regulations of the various plant quarantine acts are carried out by the local agricultural officers in the various islands; these officers are required to inspect plant imports and to arrange for the necessary fumigation and other prescribed treatment.

Much of the entomologist's time is occupied in traveling, owing to the geographical situation of the islands of the Lesser Antilles and the difficulties of steamboat travel which result in an unfortunate loss of time. Nevertheless, the pages of the *West Indian Bulletin*, the quarterly journal of the Imperial Department of Agriculture and its fortnightly publication, *The Agricultural News*, and the pamphlets that have been issued dealing with the insect pests of various crops bear witness to the excellent work that is accomplished by the Entomologist in spite of the difficulties with which he has to contend. And the same may be said of those who are responsible for entomological work in the individual West Indian colonies that I have mentioned.

OTHER IMPERIAL ENTOMOLOGICAL WORK.

Space forbids an individual treatment of the entomological work that is being carried out in scattered units of the British Empire to which reference has not been made. In many of these places the investigations that are being conducted relate

chiefly to insects and ticks concerned in the transmission of disease such as those of Dr. W. M. Aders on ticks in Zanzibar. In the Seychelles entomological observations are being made by Mr. P. R. Dupont, the Curator of the Botanical Station; in the Federated Malay States Mr. C. Strickland is studying mosquitoes and malaria, and other entomological work, particularly on locusts, is also being carried on by Mr. C. B. Holman Hunt and Mr. P. B. Richards. M. D'Emmerez de Charmony is paying attention to the insects of Mauritius, and in Cyprus the entomological work is conducted by Mr. Z. G. Solomides, who is called upon to deal with the locust plagues to which this island is subject.